**Combining stated and revealed preference methods: A dairy adoption case study of western Kenya**

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**Abstract**

The study was carried out in seven districts in western Kenya to determine factors influencing the adoption of dairy technologies. This paper looks at the complementarity in the analysis derived from the revealed preference (RP), and stated preference (SP) methods in the determination of these factors. The binary choice probit model was used for the RP method, while the ordered probit model (OPM) was used for conjoint analysis, an SP method. The SP methods are based on hypothetical choice behaviour and were used to place a value to each of the cow attributes (milk yield, disease resistance, feed requirement and price). Unlike the SP methods that have been criticized because actual choice is not observed, the RP methods, common in most adoption studies, are based on actual choices, hence the complementarity. The PPE, ethnicity, cultural values, education, income and extension influenced adoption. In some households, other reasons other than the economic reasons of rearing dairy influenced adoption, thus unfolding a unique adoption process. The willingness to pay (WTP) showed that externalities in the form of lack of information, ethnicity and farmer priorities reduced efficiency in resource use for dairy. The SP method is good at targeting interventions by explaining the households' observed behaviour, thus it gives feedback signals on efficiency of resource use and

apportions the stakeholders' effort in dairy adoption. The interventions are addressed in the perspective of the resources available.

*Key words: adoption, stated preference and revealed preference methods, conjoint, WTP, WTA*

## Introduction

In spite of the high potential for dairy and the evident benefits from it, western Kenya is one of the country's poorest areas with low milk production levels, Waithaka et al., (2002). A study by Omore, et al. (1999) shows Western and Nyanza provinces with less than 9% of the national milk output, thus qualifying as a milk deficit area. Milk production/capita is lowest in Western province. Central province, a high potential area, has a productivity of 52.8 MT/ Km2, while Nyanza, Rift valley, and Western provinces, also a high potential, have 18.4, 8.6, and 15.2 MT/Km2 respectively. In view of the opportunities for dairy in the area and the incentives from market liberalisation, the low production levels reflected major impediments to dairy, necessitating a comprehensive analysis on adoption by use of the RP and SP methods. Observed data (RP) exhibit limited ranges of variation in important variables (Karugia, 1997), thus masking vital information that can be determined by SP methods, hence the complementarity. The SP methods are relevant for both market and non-market attribute valuations (Adamowicz et al., 1993). The latter cannot be determined by RP methods. The CJ method, one of the SP methods, is used in this study to value cow attributes to explain observed choice behaviour. Inclusion of price as an attribute in the CJ method estimates is used to get WTP for other attributes (Mackenzie, 1992;Gan and Luzar, 1993). The WTP is useful during resource allocation based on social (rather than private) costs and benefits.  Markets allocate resources, and disparity between market prices and WTP may be a measure of market imperfections. In this case it is hypothesised that externalities in the form of information asymmetry, cultural practices, ethnicity, and objectives have disabled the chance to use the existing opportunities to improve dairy.

## Theoretical framework

The traditional consumer theory explains how a rational consumer chooses what to consume subject to certain constraints (Sadoulet and de Janvry, 1995) through binary choice. The goods and services chosen are an entity of different attributes, and the marginal utility measured is an aggregate of marginal utilities from different attributes of the good or service. This method used in most RP adoption methods, is not explicit in determining what technology attributes condition adopters to make a decision. The SP methods are based on the new consumer theory, which states that consumers derive utility from their attributes of a good, and not good itself (Sy et al., 1994; Tano et al., 2003). At constant utility level, the negative of the ratio of two attribute coefficients will measure the marginal rate of substitution (MRS), and the MRS turns to WTP if the cost of the product is included. This study uses the RP method to determine factors that influence adoption, and the SP method to explain this adoption.

## Methods used

Two data sets were used, and the first set for the RP method was obtained from a survey that characterized households in seven districts in western Kenya: Bungoma, Kakamega, Vihiga, Kisii, Rachuonyo, Nyamira, and Nandi in the year 2000. Population density, distance, and PPE were the spatial factors for stratification of the sampling frame, because they are key factors in determining milk production and marketing (Staal et al., 1997). Multi-stage and random sampling was done to give 1575 households across the districts. The data set covered most bio-physical and socio-economic aspects of dairy. The probit model estimated was;

$Y = \beta' X + e$, where;

Y is the depended variable, X are observable independent factors e is the error term.

The probit models were estimated, with adoption of dairy breeds, Napier production and the use of anti-helminthics as dependent variables.

The SP method started with identification of the relevant livestock attributes in the area, and they were disease resistance, feed requirement, milk yield, and price of the cows, each at three levels. Attribute combinations (profiles) were generated using the SPSS orthogonal design computer generator. The profiles were ranked by 630 households, a sub-sample of the first data set. Data on household and institutional characteristics was also obtained. The OPM was used but unlike the binary probit model, the depended variable (profile rankings were recorded with increasing preference intensities. The independent variables were the attribute levels, household characteristics, and interaction variables of the attribute levels and household characteristics.

**Results and Discussion**

Table 1 (Appendix) shows that households with on-farm income invested in dairy, but not those with off-farm income. This depicts a lack of interdependence between the farm and non-farm sector. Their priorities were mainly off-farm. Except for Napier production, gender had no significant association with dairy, meaning that both men and women had an equal chance of adopting, despite the little resources women have. Educated males showed a negative association with Napier production. Households with more land had a negative association with adoption of dairy breeds and Napier. Hence technologies that increase returns to resources are adopted when factor proportions are constrained. This also depicted the households' failure to capture the economies of scale in dairy. Dairy is not a first priority for some households. A higher dependency ratio was negatively associated with adoption of dairy breeds, thus qualifying dairy as labour intensive. Because dairy is not a first priority, most households may be reluctant to use more labour. A high population density had a low association with adoption, depicting low market orientation. Distance to the main road had minimal influence, also suggesting the low market orientation dairy is in this area. Non-significance of age and type of management means that the factors were not constraints to adoption, thus increasing the diversity of potential adopters.

Table 2 (Appendix) gives more explanation on the observed adoption rates. Dividing the attribute level coefficient by the price coefficient, and getting the negative of the result gives the marginal WTP if it is positive. Negative values mean marginal willingness to accept (WTA). Typical households have a WTP of KSh 8,500 for a cow with a higher milk yield. This difference is almost the same as the difference between the observed price of the zebu and the dairy cross, but less than the actual price difference between the dairy cross and the high grade cow. This makes it easier for households to move from having a zebu to a dairy cross than from a dairy cross-breed to a high-grade breed, thus explaining why there were more dairy cross-breeds than high-grade breeds. The observed price of the zebu was between KSh 4,000 and KSh 8,000, and that of the dairy cross was between KSh 13,000 and KSh 15,000, while the pure-grade's was between KSh 25,000 and KSh 30,000. The marginal WTP for low feed requirement was KSh 4,500, which was within the observed price band of the zebu, thus showing why it is common to get many households with zebu cattle. Milk yield was the most important attribute, followed by feed requirement and lastly disease resistance. A typical household has a WTA of KSh 15,000 as compensation to accept a cow with high feed requirement and KSh 16,000 to have one with high disease resistance. The WTP and WTA for the different attribute levels of the same attribute are not the same, and this suggests the existence of inefficiencies. The measures of WTP and WTA can only be equal in a perfectly competitive environment (Markandya, 2000). For instance the differences in the marginal WTP and marginal WTA for a cow with low feed requirement is because households are not sure of feed availability if they had a cow with high feed requirement, therefore they would want to be compensated KSh 15,000 for the lower utility. At the same time they would want to pay much less for a cow with low feed requirement. In this case study, lack of knowledge of the existing feed resources causes this divergence.

It is important to look at the MRS of other attributes for milk yield, the most important attribute. In addition, an individual's decision to adopt a certain breed is a trade-off among attributes. The MRS of disease resistance for milk yield was;

$$-\left(\frac{-0.32}{0.17}\right) = 1.88 \text{ litres.}$$

This means that, other attributes constant, a typical household trades off higher

disease resistance for 1.88 litres of milk/cow /day. This gain would only be beneficial if animal health services are stepped up to control diseases. A typical household also trades off lower feed requirement for 1.76 litres of milk/cow/day. This trade-off is encouraged in the study area because of the diversity of the feeds available. These figures show that an improved dairy breed (IDB) gives a marginal benefit of 3.64 (1.88 +1.76) litres of milk/cow/day with more feed and more control of diseases.

Factors that explain the variation of adoption rates of different breeds were PPE, extension, Kisii, and Nandi, off-farm income, education, and cultural values. The overall marginal WTP for a specific household group can be obtained by summing up all marginal WTP values for the main effects in Model 1 and interaction effects for that household group in Model 2. For instance the marginal WTP for milk yield for a household that has received extension services in Kisii was Ksh 11,833, while the marginal WTP for milk yield for a household that has received extension services in Nandi was KSh 11,166. This means that the market does not give the true value attached to milk yield by different household groups, thus making CJ analysis effective in doing this. Households located in areas with a PPE greater than one increased the marginal WTP for high milk yield by KSh 1,000. They traded off 2.75 litres of milk/day [(-0.32+-0.23)/(0.17+0.03)] for a cow with high disease resistance, and 2.12 litres of milk/day [(-0.25+-0.09)/(0.13+0.03)] for a cow with a lower feed requirement. The high trade-off for disease resistance is justified because a high PPE is accompanied by high disease incidences, making such households sensitive to disease resistance. However the high trade-off for low feed requirement is unexpected because areas with high PPE have abundant fodder, leading to the conclusion that households in high PPE areas do not exploit this opportunity.

Households that received extension services would spend an additional KSh 666. This is small compared to the marginal WTP for other factors. The Kisii would spend an additional KSh 3,333, while the Nandi would spend KSh 2,666 more to have a cow with high milk yield. Therefore the effort from extension should be increased. This explains there were more IDBs in Kisii and Nandi than other areas. The Kisii are willing to pay an additional Ksh 10,333 for a cow with low feed requirement while the Nandi would give up twice that amount. The result is quite understood for the Kisii because they have small parcels of land, making fodder availability more difficult. Most households in the study area rely on fodder from the farm. This high marginal WTP for low feed requirement therefore indicates scarcity of feed in Kisii. The high marginal WTP for the Nandi is not easy to interpret. It could be due to the fact that natural pasture is easily obtained from their large herd sizes, and so they would not want to spend extra resources on additional fodder. This result and the one from PPE show that extension should indicate the different sources of feed and feed preservation methods. Education of the household head gave a marginal WTP for high feed requirement. This is not surprising because a higher level of education increases the ability to know more sources of fodder. Furthermore Table 1 shows that education increases the probability of Napier production by 1%.

Households that valued cattle for cultural functions (trd) had a WTA of Ksh 1,000 as compensation for having a cow with high milk yield. This shows that they value milk yield less than the typical household, giving an indication that they did not rear cattle with the main objective to have a significant marketable surplus. These preferences decreased the probability of adopting the IDB's, explaining why the zebu is predominant in western and Nyanza province, households that uphold cultural functions like dowry.

Households with off-farm income show attribute valuations that are quite inconsistent with a rational decision maker. They show WTA for both high and low disease resistance at the same time, and also show WTA for feed requirement. This result could be because their priorities were elsewhere (mainly off-farm) thus they did not take ranking of the profiles seriously. This only confirms what was noted earlier (Table 4.10) that this category of households had a lower probability of rearing dairy.

The disparity in the real and implicit marginal price values is seen through the CJ. These results explain the differences in the adoption rates of the different dairy breeds. The CJ also reveals the inefficiencies in the use of the resources that can be used to develop dairy.

## Conclusions

The PPE, information and households' priorities are the key factors influencing adoption of dairy technologies. The RP and SP methods show consistency. Milk yield is the most important attribute, but with variations across socio-economic groups, due to milk yield trade-offs for other attributes, because of their circumstances and broader objectives of rearing livestock, hence the observed variations in the adoption rates. Thus the hypothesis that externalities in the form of information asymmetry, cultural practices, ethnicity, and objectives have disabled the chance to use the existing opportunities to improve dairy is true.

## Recommendations

Improved dairy breeds should be adopted because of the immense benefits and the high potential for these breeds in the study area. The Government should take the lead in giving information at this initial stage of dairy development, because it has the infrastructure established in the form of extension agents. At this stage, information on dairy is a public good, hence unattractive to the private sector. Extension agents should emphasise crop-livestock interaction, encourage the use of the available labour, larger land sizes, off-farm income, and the ready markets to improve dairy. Additional labour force is needed in crop-livestock interaction, presenting a classic case of efficient job creation, where additional labour force can still increase productivity. Thus the productivity potential of existing resources should be exhausted before moving to other resources. Due to limited Government resources, and due to the risk-averse attitude and cultural rigidities, farmer groups are better for faster, cost-effective flow of information, and support from one another. Women groups should be supported to have dairy projects that recognise their constraints and enable them have control of the benefits. Lastly, the CJ is recommended in valuing resources in imperfect market situations.

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# Appendix

**Table 1: Marginal Effects(%) from the single probit estimates**

| **Independent variable** | **impdairy** | **Napier** | **Antihelminthics** |
|---|---|---|---|
| inc (Monthly Income category of the household) 1=above ksh 5,000, 0=below ksh 5,000 | 13 (0.11) *** | 0.9 (0.13) *** | 16 (0.11) *** |
| gender (gender of the household head) 1=male, 0=Female | -0.4(0.19) | 20(0.23) *** | 1(0.19) |
| Present land size (land size in acres) | -0.2(0.01) *** | -1(0.01) *** | 1(0.01) |
| Fodder10ago (Did you grow fodder 10 years ago?) 1=Yes, 0=No | | 8 (0.14)*** | |
| Dairy10 (Did you have dairy breeds 10 years ago?)1=Yes, 0=No | 42(0.12) *** | | 17 (0.11) *** |
| TNUrdtype3km (The distance by earth road from the household to the nearest tarmac road) | -1(0.02) | -1(0.02)* | -0.3(0.02) |
| exttopicsolstck (received extension services on dairy production?) 1=received, 0=Otherwise | 16 (0.19) ** | 21(0.21) | 21(0.19) *** |
| exttopicsolstck·education | -0.5(0.02) | 10(0.02) *** | -1(0.02) |
| Ownermanager (owner of the farm as well as manager?) 1=Yes, 0=No | -0.2(0.10) | -4(0.13) | 0.2(0.1) |
| Education (education level of the household head) | 1(0.03) | 1(0.03)* | 1(0.03) |
| gender·education | 1(0.03) | -1(0.03)* | -0.2(0.03) |
| Kisii (ethnic group of the household head) 1=Kisii, 0=Luhya | 16 (0.12) *** | 21 (0.17) *** | 19(0.12) |
| Popn (Population density in persons/km$^2$at 5 km radius) | 1.2(0.0001) | 2(0.0002) *** | |
| PPE | 5.4(0.34) *** | 9(0.55) *** | 1.9(0.33) |
| dependency (ratio of pre-school and school-going household members to adults in the household) | -3(0.04) ** | -1(0.05) | -1(0.04) |
| OfffarmYrank (Off-farm income as main source of income)1=Yes,0 =No | -8(0.10)** | -3(0.12) | -6(0.09)ns |
| Hhage (age of the household head in years) | 0.1(0.004) | 0.2(0.01) | 0.2(0.004) |
| Constant<br>observations<br>Wald chi-square (17) | -1.63 (0.47)***<br>921<br>217 | -3.7 (0.62) ***<br>921<br>215 | 0.60(0.47)<br>921<br>152 |
| Percent of correct prediction:<br>Adopters<br>Non-adopters<br>Overall | <br>79.45<br>69.40<br>74.92 | <br>87.91<br>77.00<br>85.56 | <br>73.72<br>62.77<br>70.47 |

*Source: Author's Compilation. * means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level,*

**Table 2: Marginal WTP estimates (in Kenya shillings) for cow attributes**

| | A typical Household (model 1) | | Analysis with household characteristics (model 2) | |
|---|---|---|---|---|
| **Attribute levels** | | **WTP/WTA** | | **WTP/WTA** |
| Low disease resistance | -0.32(0.03)*** | -16,000 | | |
| Price | -.00002(2.46($10^{-6}$))*** | | | |
| Milk yield | 0.17(0.005)*** | 8,500 | | |
| Low feed requirement | 0.09(0.03)*** | 4,500 | | |
| High feed requirement | -0.30(0.03)*** | -15,000 | | |
| High disease resistance | -0.02(0.03) | | | |
| Block5 | -0.07(0.04) | | | |
| **Interactions** | | | | |
| Milk yield●Kisii | | | 0.10(0.01)*** | 3,333 |
| Milk yield●trd | | | -0.03(0.01)*** | -1,000 |
| Milk yield●Nandi | | | 0.08(0.02)*** | 2,666 |
| Milk yield●high PPE | | | 0.03(0.01)*** | 1,000 |
| Price●high PPE | | | 0.00002(5.59($10^{-6}$)*** | |
| Extension●milkyield | | | 0.02(0.01)** | 666 |
| Low feed requirement ● Kisii | | | 0.31(0.16)** | 10,333 |
| Low feed requirement ● Nandi | | | 0.64(0.22)*** | 21,333 |
| Low feed requirement ● off-farm income | | | -0.50(0.13)*** | -16,666 |
| High feed requirement ● high PPE | | | -0.25(0.13)* | 8,333 |
| High feed requirement ●off-farm income | | | -0.39(0.13)*** | -13,000 |
| High feed requirement ●Education | | | 0.03(0.01)*** | 2,000 |
| High disease resistance ●off-farm income | | | 0.29(0.14)** | 9,666 |
| Low disease resistance ●off-farm income | | | 0.23(0.13)* | 7,666 |
| Low disease resistance ●high PPE | | | -0.23(0.13)* | -7,666 |
| LR<br>No. of observations<br>Degrees of freedom | 1707***<br>3146<br>14 | | 1938***<br>3126<br>59 | |

*Source: Author's Compilation. * means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level,*